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Limnocythere curvispinosa sp. nov. (Crustacea, Ostracoda) from two ancient lakes in the Xiaojiang Fault zone, Yunnan Province, southwestern China

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Abstract

Ancient lakes often harbor endemic species that are invaluable for studying adaptive radiation and speciation. In Yunnan Province, southwestern China, a number of ancient lakes emerged as a result of Cenozoic tectonic activities. Within these lakes, ostracods constitute a crucial component of the ecosystems, yet they remain poorly studied. Here, we describe *Limnocythere curvispinosa* **sp. nov.** (Limnocytheridae Sars, 1925) from Fuxian and Yangzong Lakes in east-central Yunnan. This new species belongs to the *L. stationis* group based on its posteriorly inclined dorsal valve margin and the reduced seventh limb. It can be distinguished from other species in this group by the three long, curved dorsal spines on the right valve, the small antero-dorsal spine on the left valve, and the unique morphology of the hemipenis. Our data indicate that *Limnocythere curvispinosa* **sp. nov.** colonized Yangzong Lake by the Early Holocene at the latest, but it is uncertain if it still occurs there today. Some females and a few males of this species still live in Fuxian Lake. Together, *Limnocythere curvispinosa* **sp. nov.**, *Limnocythere xinanensis* Zhao, 1987, and another undescribed but closely related species represent a small evolutionary lineage within the *L. stationis* group that has inhabited southwestern China since the Early Pleistocene.

Key Words

Cytheroidea, Fuxian Lake, paleontology, taxonomy, Yangzong Lake

Introduction

Ancient lakes are geologically long-lived lacustrine systems that originated before the late Pleistocene glaciations (Martens 1997). Often with relatively high biodiversity and endemism, these lakes have emerged as key areas for studying speciation and evolutionary radiation (Martens et al. 1994; Martens 1997; Martens and Schön 1999; Wilson et al. 2004; Vaillant et al. 2011; Karanovic et al. 2023). Due to their importance in the lake ecosystem, the ostracod faunas of a few of the world's ancient lakes have been intensively studied. These include Lakes Baikal (Schön and Martens 2004, 2012; Karanovic et al. 2023), Tanganyika (Wilson et al. 2004; Schön and

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Martens 2012), and Biwa (Schön and Martens 2004; Smith and Janz 2008, 2009). Research on the ostracods in China's ancient lakes has been limited, particularly regarding the taxonomic aspect (Yang and Huang 1983; Huang et al. 1984; Zhai et al. 2025), which corresponds with the inadequate study of the country's extant ostracod fauna in general (Yu et al. 2009; Zhai et al. 2023).

Yunnan Province is located on the Yunnan–Guizhou Plateau in southwestern (SW) China. Bordering the Qinghai–Tibetan Plateau to its northwest and the lowlands to the south and southeast, the province exhibits a substantial altitudinal gradient, diverse climates, and consequently high biological diversity. Yunnan ranks high among Chinese provinces in terms of both biodiversity and endemism, serving as a significant origin and differentiation center for numerous evolutionary lineages (Yang et al. 2004; Liu et al. 2021). Complex tectonic activities in Yunnan Province generated a number of plateau lakes, including Fuxian and Yangzong, ancient lakes that originated in or before the Early Pleistocene (Song et al. 1997; Wang and Dou 1998). Research on the ostracods in these lakes remains inadequate, as it covers only a small fraction of the province's known ostracod diversity (see the checklist in Zhai et al. 2023) and has revealed no significant endemism (Yu et al. 2010; Liu and Xie 2014; Yu et al. 2022). Some taxonomic studies of the ostracods in Yunnan's ancient lakes were carried out on valve material alone (Yang and Huang 1983; Huang et al. 1984), which means the morphology of the inner parts was undescribed, and potential nomenclatural bias may have occurred.

In this study, we describe *Limnocythere curvispinosa* sp. nov. from modern habitats in Fuxian Lake and the Holocene sediments of Yangzong Lake. We compare the new species with related Quaternary and extant taxa and discuss potential factors influencing its population dynamics in Yangzong Lake during the Holocene. Our study contributes to the knowledge on the biodiversity and evolution of the crustaceans in the ancient lakes in SW China.

Terminology

Abbreviation list. **Ad-*n***—the n^{th} juvenile stage before the adult stage; **A1**—antennule; **A2**—antenna; **bs**—basis; **cal yr (or ka) BP**—calendar years (or kiloanni) before present (present = 1950 AD); **cx**—coxa; **cop**—copulatory process; **Cp**—carapace; **dor**—dorsal view/side; **DH**—horizontal distance between highest point of valve (antero-dorsal angle) and anterior end; **DH/L**—ratio between DH and valve length; **dl**—distal lobe of hemipenis; **EC**—electrical conductivity; **en**—endopodal segment; **ext**—exterior view/side; **GL**—genital lobe; **H**—height;

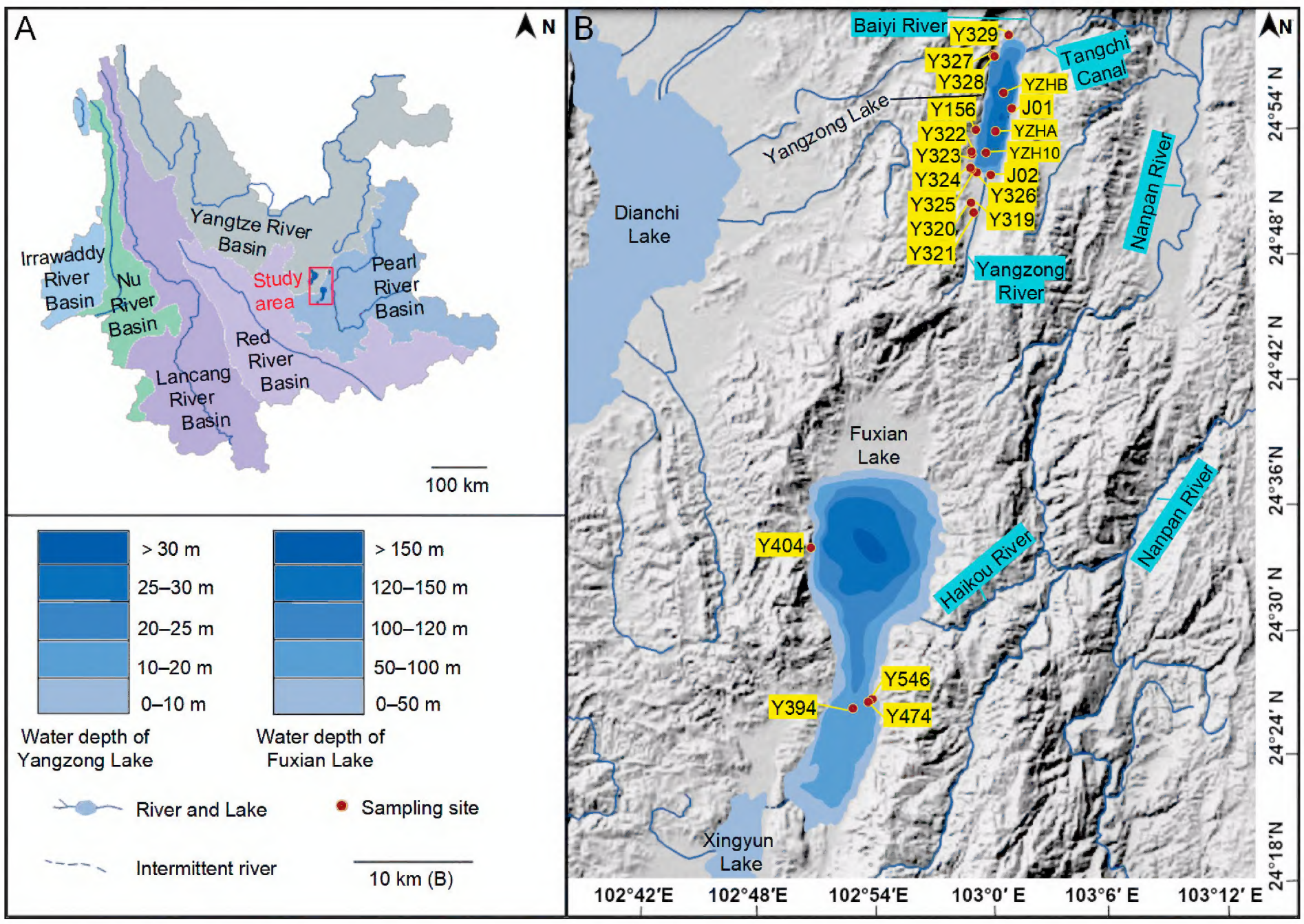

Figure 1. Maps. **A.** River basins of Yunnan Province in southwestern China; **B.** Hydrological settings of the study area and sampling localities. Isobathic lines of Yangzong and Fuxian Lakes follow Fan et al. (2023) and Cui et al. (2008), respectively. Both maps are redrawn from https://yunnan.tianditu.gov.cn/index.

H/L—ratio between height and length; **hkp**—hook-like process; **Hp**—hemipenis; **int**—interior view/side; **L**—length; **LV**—left valve; **L5/L6/L7**—fifth/sixth/seventh limb; **m a.s.l.**—meters above sea level; **Md**—mandible; **msc**—median sclerites; **Mx**—maxillula; **n**—number of values available for calculation; **na**—not available; **pt**—protopod; **psc**—proximal sclerite; **RV**—right valve; **SA**—sloping angle of dorsal margin of valve; **SN**—site number; **T**—temperature; **WD**—water depth. Terminology of the appendage chaetotaxy follows that of Meisch (2000), which had been revised from Broodbakker and Danielopol (1982) and Martens (1987).

Study area

Fuxian and Yangzong are tectonic lakes that developed in the western branch of the Xiaojiang Fault zone (Fan et al. 2023) in Yunnan Province of SW China. Both lakes were formed at the latest by the Early Pleistocene (Song et al. 1997; Wang and Dou 1998). Hydrologically, they belong to the Pearl River Basin, one of the six drainage basins of Yunnan (Fig. 1A). Both lakes are drained by tributaries of the Nanpan River that joins the main stream of the Pearl River in its lower reaches.

Fuxian Lake (24°21'28"–24°38'00"N, 102°49'12"–102°57'26"E) has a maximum depth of 155 m and a surface area of 211 km^2 when the water level is at 1721 m a.s.l. (Wang and Dou 1998). The lake, fed by a multitude of small streams and ditches, is drained by the Haikou River in the east. An intermittent river connected the lake with Xingyun Lake in the southwest when the lake level was relatively high (Wang and Dou 1998), but in recent years the riverbed has been dry.

Yangzong Lake (24°51'24"–24°57'58"N, 102°58'47"–103°01'41"E) is located to the northeast of Fuxian Lake, separated from the latter by mountains with elevations over 2000 m a.s.l. (Fig. 1B). It has a surface area of 32 km^2 and a maximum water depth of ca. 30 m when the lake level is at 1770 m a.s.l. (Deng et al. 2008; Fan et al. 2023). With a catchment area of ca. 192 km^2, the lake is fed by direct precipitation, surface runoff, as well as groundwater input (Deng et al. 2008; Fan et al. 2023). It receives two major surface inflows, including the Yangzong River originating from the mountain area in the south and the Baiyangshan Canal (built in 1955 AD; Yiliang County Local Chronicles Compilation Committee 1998) diverging from the Baiyi River in the northeast (Fig. 1B). The only outflow of the lake is Tangchi Canal, excavated in 1396 AD (Yiliang County Local Chronicles Compilation Committee 1998). As we observed in the field, it drains the lake from a position about 100 m away from the entrance of the Baiyi River. The Baiyi River generally parallels Tangchi Canal in its distal section and crosses over the latter at a distance of 1.5 km from its entrance into the lake (Fig. 1B) (field investigation by the present authors). From about 1736 AD to 1795 AD, Tangchi town was gradually established, and a thermal power plant was built on the northeast of the lake in 1959 AD (Yiliang County Local Chronicles Compilation Committee 1998). Subsequently, many factories, such as fertilizer plants and cement plants, were successively set up in 1972 AD (Yiliang County Local Chronicles Compilation Committee 1998).

Materials and methods

Sampling

From October 2021 to May 2025, four sites in Fuxian Lake, seven sites in Yangzong Lake, and eight sites from the small waterbodies around Yangzong Lake were sampled for extant ostracods (Fig. 1B, Table 1). In habitats with water depths shallower than 1 m, a 180 μm mesh was used to sieve the macrophytes and the bottom substrate. In deeper habitats, the surface sediments were sampled with either gravity corers (UWITEC gravity corer at sites J01, J02, and YZH10; XC-ZZ gravity corer at site Y394) or grabs (Peterson XD-32 grab at sites Y404 and Y474 and Vanveen XC-V16 grab at site Y546). The top ca. 2 cm of substrate was sieved with a 180 μm mesh. At all sites, the residues retained on the mesh were preserved in 70% ethanol. The bottom water of sites Y394, Y474, and Y546 was sampled with a JC-800D cup-type water sampler. EC, T, and pH of the bottom waters were measured with a SANXIN PC5 device directly in the field for some of the sampling sites.

The fossil material analyzed in this study comes from two sediment cores retrieved from the central parts of Yangzong Lake with a 60 mm piston corer of the UWITEC drilling platform (Fig. 1B, Table 1). YZHA was drilled to a depth of 14.35 m beneath the sediment surface, and YZHB was drilled to a depth of 11.25 m beneath the sediment surface. Both cores were initially sliced at 0.5 cm intervals and then dried. Each ostracod sample analyzed in this study was made by combining two adjacent samples together, representing an interval of 1 cm and a time span of 5.4–15.5 years in core YZHA and 18.6–32.4 years in core YZHB, depending on the sedimentation rate. The charcoal and plant macrofossil material of 12 samples from YZHA and seven samples from YZHB were dated with the AMS ^{14}C method (Fan et al. accepted). Based on the chronological data, core YZHA covers almost the entire Holocene, whereas core YZHB dates back to the Late Pleistocene.

Laboratory analysis

For the analysis of living ostracods, ethanol-preserved samples were transferred to a Petri dish and the ostracods were picked under a JIANGNAN SZ6000 stereomicroscope. The specimens were carefully dissected using finely sharpened iron needles and viewed under a JIANGNAN JSZ6S stereomicroscope. The inner parts were sealed in Hydro-Matrix® (Dr. Richard Rudnicki, Micro Tech Lab, Austria) and examined with a SHANGGUANG

Table 1. Habitat characteristics and ostracod composition of the sampling sites. EC, T, and pH, when available, were measured for the bottom water.

SN and date	Habitat	Coordinates and altitude (m a.s.l.)	WD (m)	EC (μS cm^{-1})	T (°C)	pH	Substrate and vegetation	Ostracods
J01-20211014	Yangzong Lake	24°54'49"N, 103°01'02"E, 1770	8.4	na.	na.	na.	Mud, macrophytes	22 *Cypridopsis vidua*, 3 Timiriaseviinae sp.
J02-20211014	Yangzong Lake	24°51'39"N, 102°59'43"E, 1770	5.7	na.	na.	na.	Mud, macrophytes	8 *C. vidua*, 2 *Physocypria kraepelini*
Y156-20211015	Yangzong Lake	24°53'53"N, 102°59'00"E, 1770	0.4	460	19.8	8.90	Mud, dense macrophytes	311 *C. vidua*
Y319-20240612	Flooded field	24°50'18"N, 102°58'41"E, 1780	0.1	639	21.3	7.45	Mud, grasses and floating plants	26 *P. kraepelini*, 5 *C. vidua*, 1 *Heterocypris incongruens*
Y320-20240612	Ditch	24°50'18"N, 102°58'40"E, 1780	0.2	690	20.8	7.84	Mud, a few macrophytes	15 *Stenocypris* sp., 7 *Fabaeformiscandona subacuta*, 3 *P. kraepelini*, 2 *C. vidua*, 1 *H. incongruens*
Y321-20240612	Lotus field	24°49'49"N, 102°58'57"E, 1800	0.4	825	22.6	8.81	Mud and a little sand, lotus	None
Y322-20240612	Pond	24°52'41"N, 102°58'54"E, 1770	0.5	176	23.2	7.43	Mud, dense macrophytes and emergent plants	15 *C. vidua*
Y323-20240612	Yangzong Lake	24°52'34"N, 102°58'55"E, 1770	1.0	416	24.2	9.27	Sand, short macrophytes	4 *C. vidua*
Y324-20240612	Yangzong Lake	24°51'57"N, 102°58'50"E, 1770	0.1	413	25.7	9.19	Sand and gravels, abundant short macrophytes	3 *C. vidua*, 2 *Limnocythere* sp.
Y325-20240612	Pond	24°51'50"N, 102°58'52"E, 1770	0.5	605	25.0	7.86	Mud and sand, abundant macrophytes	9 *P. kraepelini*
Y326-20240612	Pond	24°51'40"N, 102°59'02"E, 1770	0.2	469	26.2	8.15	Mud and sand, dense grasses and a few filamentous algae	2 *Ilyocypris* sp., 1 *F. subacuta*
Y327-20240612	Pond	24°57'22"N, 103°00'06"E, na.	0.1	633	26.9	7.97	Mud and sand, abundant grasses	3 *P. kraepelini*, 3 *F. subacuta*, 3 *C. vidua*, 5 *H. incongruens*
Y328-20240612	Yangzong Lake	24°57'20"N, 103°00'08"E, 1770	0.4	406	28.8	9.33	Gravels and sand, patches of macrophytes	19 *C. vidua*
Y329-20240612	Pond	24°58'06"N, 103°00'38"E, 1770	0.5	610	28.3	8.83	Mud, grasses	2 *P. kraepelini*, 2 *Stenocypris* sp., 1 *F. subacuta*
Y394-20240824	Fuxian Lake	24°27'00"N, 102°52'45"E, 1720	77.0	323	15.7	7.91	Mud, no vegetation	24 *Limnocythere curvispinosa* sp. nov. (other ostracods to be published elsewhere)
Y404-20240824	Fuxian Lake	24°34'11"N, 102°50'39"E, 1720	16.0	na	na	na	Mud, no vegetation	1 *L. curvispinosa* sp. nov. (other ostracods to be published elsewhere)
Y474-20250222	Fuxian Lake	24°27'13"N, 102°53'32"E, 1720	68.0	340	14.3	8.35	Mud, no vegetation	2 *L. curvispinosa* sp. nov. (other ostracods to be published elsewhere)
Y546-20250522	Fuxian Lake	24°27'18"N, 102°53'42"E, 1720	38.0	327	15.8	8.25	Mud, no vegetation	At least 43 *L. curvispinosa* sp. nov. (other ostracods to be published elsewhere)
YZH10-20211014	Yangzong Lake	24°52'38"N, 102°59'35"E, 1770	23.8	na.	na.	na.	Mud, no vegetation	26 *C. vidua*
YZHA-202110 (core)	Yangzong Lake	24°53'50"N, 103°00'05"E, 1770	27.7	na.	na.	na.	Mud, no vegetation	Dominated by *F. subacuta* and *L. curvispinosa* sp. nov.
YZHB-202110 (core)	Yangzong Lake	24°55'34"N, 103°00'26"E, 1770	26.1	na	na	na	Mud, no vegetation	Dominated by *F. subacuta* and *L. curvispinosa* sp. nov.

Note: The ostracod data of the samples J01, J02, Y156, and YZH10 were partly published in Zhai et al. (2023), when the picking procedures of J02 and Y156 were not accomplished. The ostracod data have been updated by picking and counting all the ostracods in these two samples.

XSP-12CA transmitted light microscope. Photographs of appendages, which were taken with a CANON EOS 5D Mark IV camera connected to this microscope, were traced in Microsoft PowerPoint 2019 to produce line drawings, with fine details at different focus horizons checked simultaneously under the microscope. The valves were imaged with a HITACHI Regulus 8100 scanning electron microscope (Advanced Analysis and Measurement Center, Yunnan University) after coating with gold.

Fossil ostracod valves were extracted from the core sediments with a method slightly modified from Zhai et al. (2010). For each sample of 0.24–2.05 g (mostly between 1 and 2 g) of dried sediment, 60 ml of 5% H_2O_2–0.1% Na_2CO_3 solution (pH 8–9) was added to disaggregate the sediment for 24 h. The sample was then sieved in water with a 63 μm mesh. The residue retained on the mesh was collected, diluted with water, transferred to a number of black glass plates as suspension drops with a pipette, and then air-dried for ca. 24 h. The dried sample was examined under a JIANGNAN SZ6000 stereomicroscope for ostracods. It is noted that we used a lower concentration of H_2O_2 than Zhai et al. (2010, 2011) did (those authors used

10% H_2O_2). This is because the organic matter contents are generally high in our samples, and a lower concentration of H_2O_2 helps to control the intensity of reaction. We also arranged the sieved suspension on the glass plates as separate drops rather than stripes, as Zhai et al. (2010, 2011) did, in order to facilitate the counting of ostracod valves. All specimens investigated in this study are housed in the Yunnan Key Laboratory for Palaeobiology, Institute of Palaeontology, Yunnan University, Kunming, China.

The intraspecies variation of ostracod valve outlines was analyzed with the geometric morphometric method. Each valve was placed exterior upwards on a glass slide and imaged at 200× magnification using an XSP-12CA transmitted light microscope equipped with a CANON EOS 5D Mark IV camera. The valve outline was digitized with the software TPSDIG2 (v. 2.31) (Rohlf and Bookstein 1990; Rohlf 2017). Each outline obtained was relocated (with the geometric center at [0, 0]), rotated (with the antero-ventral and postero-ventral parts rested on the horizontal axis; cf. Danielopol et al. 2022, Fig. 3B), flipped if necessary to obtain the same orientation, and standardized for a surface area of 5000 before comparison. Heights and lengths of all valves were measured from the abovementioned microscopic images with the software GIMP (v. 2.10), where the antero-ventral and postero-ventral margins were aligned horizontally.

Results

A new species, with inner morphological characters recovered from Fuxian Lake and valve material recovered from the sediment cores of Yangzong Lake, is described herein.

Systematic description

Order Podocopida Sars, 1866
Superfamily Cytheroidea Baird, 1850
Family Limnocytheridae Sars, 1925
Subfamily Limnocytherinae Sars, 1925
Genus *Limnocythere* Brady, 1867

***Limnocythere curvispinosa* sp. nov.**

https://zoobank.org/D9AF6BFC-0379-4225-80F2-DB594AC426C4

Figs 2–7

?1999 *Limnocythere subornamenta* Hou, 1982—Liu and Lu: 411, pl. I, fig. 12.

Type locality. Site Y394 (Fig. 1B, Table 1), southern part of Fuxian Lake, Yunnan Province, China (24°27'00"N, 102°52'45"E, water depth 77.0 m).

Type material. ***Holotype*:** dissected female (WOC441), from type locality. ***Allotype*:** dissected male (WOC694), from site Y474. ***Paratypes*:** nine dissected females (WOC442–WOC445 and WOC451–WOC455) from type locality (Fig. 1B, Tables 1, 2).

Other material examined. Twelve undissected females from type locality, one dissected female (WOC431) from site Y404, two dissected females (WOC686, WOC687) and 41 undissected females from site Y546, and one dissected female (WOC695) from site Y474 (Fig. 1B, Table 1). A large number of valves from sediment cores YZHA and YZHB.

Derivation of name. From Latin *curva* and *spina*, denoting the three posteriorly curved spines on the dorsal margin of RV.

Dimensions. Female LVs (n = 15) L 404–469 µm (averaging 436 µm), H 230–257 µm (averaging 242 µm), H/L 0.535–0.575 (averaging 0.556). Female RVs (n = 15) L 415–465 µm (averaging 436 µm), H 227–256 µm (averaging 241 µm), H/L 0.531–0.573 (averaging 0.553). Female LVs 1 to 6 µm longer than RVs of same individual, averaging 3 µm. Male LVs (n = 2) L 411–437 µm (averaging 424 µm), H 213–233 µm (averaging 223 µm), H/L 0.518–0.533 (averaging 0.526). Male RVs (n = 3) L 423–430 µm (averaging 426 µm), H 219–230 µm (averaging 225 µm), H/L 0.518–0.535 (averaging 0.529). See Tables 2, 3 for detailed measurements.

Diagnosis. Small to intermediate-sized *Limnocythere*. Dorsal margin of valve inclined posteriorly (feature of *L. stationis* group). Posterior section of dorsal margin of RV with three prominent, posteriorly curved spines in adult and late juveniles, with less than three spines in instars younger than Ad-3. Antero-dorsal corner of LV with one (rarely two or absent) small anteriorly curved spine. Male Cp more elongate than female, with less inclined dorsal margin. Posterior area of Cp not laterally inflated in either sex. Valve surface with reticulation, and sometimes with one prominent node in postero-ventral area. Sizes of thoracic legs L6 > L5 > L7. Postero-ventral seta present on protopods of all thoracic legs. Male Hp slender, with triangular distal lobe. Female genital lobe saddle-shaped.

Description (referring to female unless otherwise noted). Valves sub-reniform in lateral view (Fig. 2A–D). Dorsal margin straight or nearly straight, strongly inclined posteriorly. Posterior section of RV dorsal margin with three prominent, usually posteriorly curved spines. Length of spines usually 20–30 µm. Antero-dorsal corner of LV with one small anteriorly curved spine (Fig. 2A, C), rarely two (Fig. 3I, K) or absent. Such rare morphological variations found in both juveniles and adults. Anterior margin broadly rounded. Posterior margin narrowly rounded. Ventral margin concave. Two shallow vertical sulci present. Anterior sulcus originating near antero-dorsal corner, short (Fig. 2A, B, white arrowheads). Posterior sulcus extending from dorsal margin to slightly above mid-height (Fig. 2A, B, yellow arrowheads). Anterior and posterior sides of posterior sulcus each with one blunt bulge. Adductor muscle scars situated in elongate depression immediately below posterior sulcus. Valve surface with sparsely or densely arranged reticulation. Postero-ventral area of valve sometimes with a prominent rounded node (Figs 2A, B, 3H, J), a phenomenon comparable to variable noding in some other non-marine ostracods (Yin et al. 1999; Van Harten 2000).

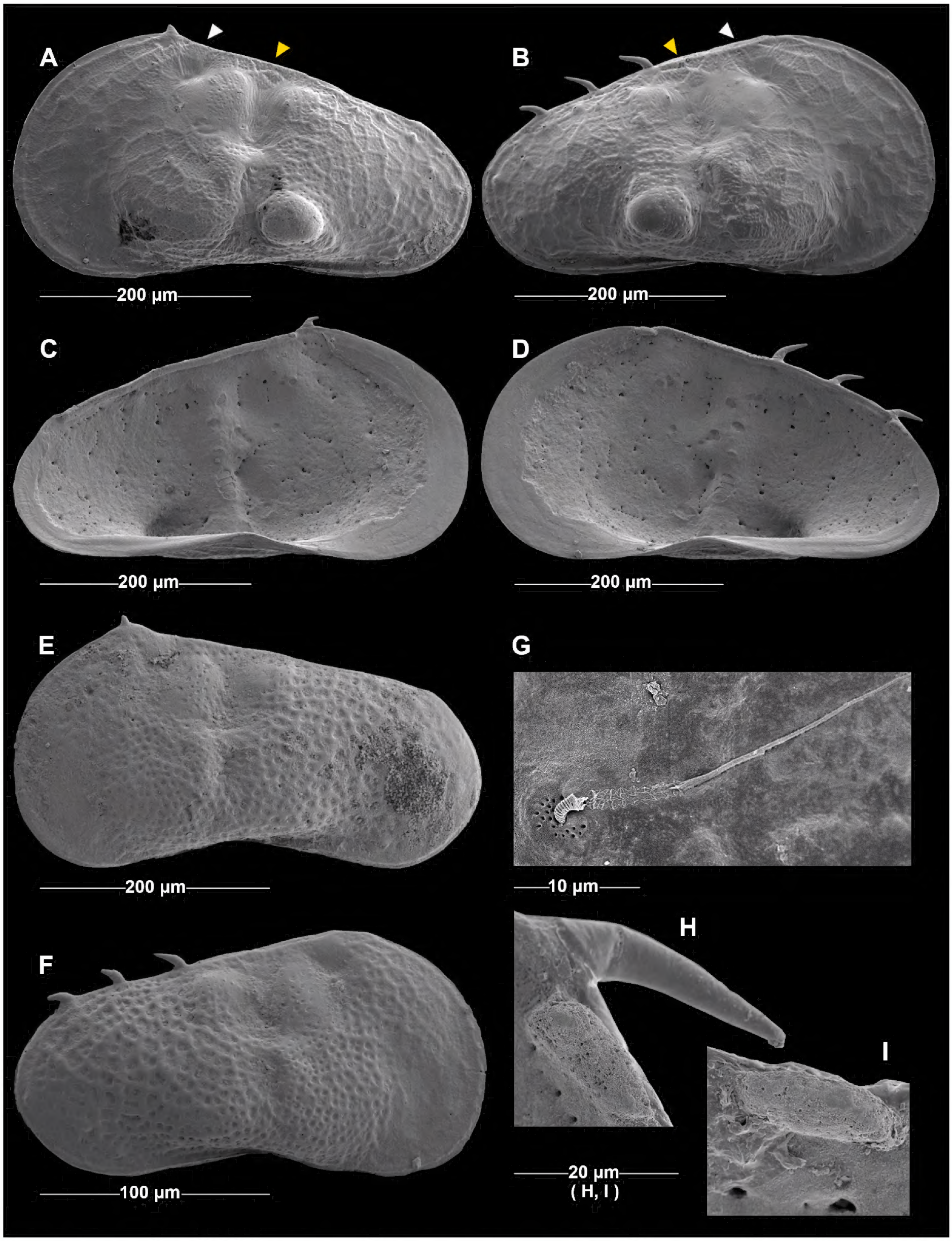

Figure 2. *Limnocythere curvispinosa* sp. nov. from Fuxian Lake (**A–D, G–I**, living specimens) and Yangzong Lake (**E–F**, fossil valves), China. **A.** Female LV, ext (WOC441, holotype); **B.** Female RV, ext (WOC441, holotype). White and yellow arrowheads in **A** and **B** point to the anterior and posterior sulci, respectively; **C.** Female LV, int (WOC442); **D.** Female RV, int (WOC442); **E.** Male LV, ext (YZHA-a'1-54); **F.** Male RV, ext (YZHA-a'1-32); **G.** Detail of a sieve pore and its seta on the exterior surface of **B**. Note the annulated proximal section of the seta; **H.** Posterior dorsal spine and posterior hinge tooth of **D**; **I.** Anterior hinge tooth of **D**.

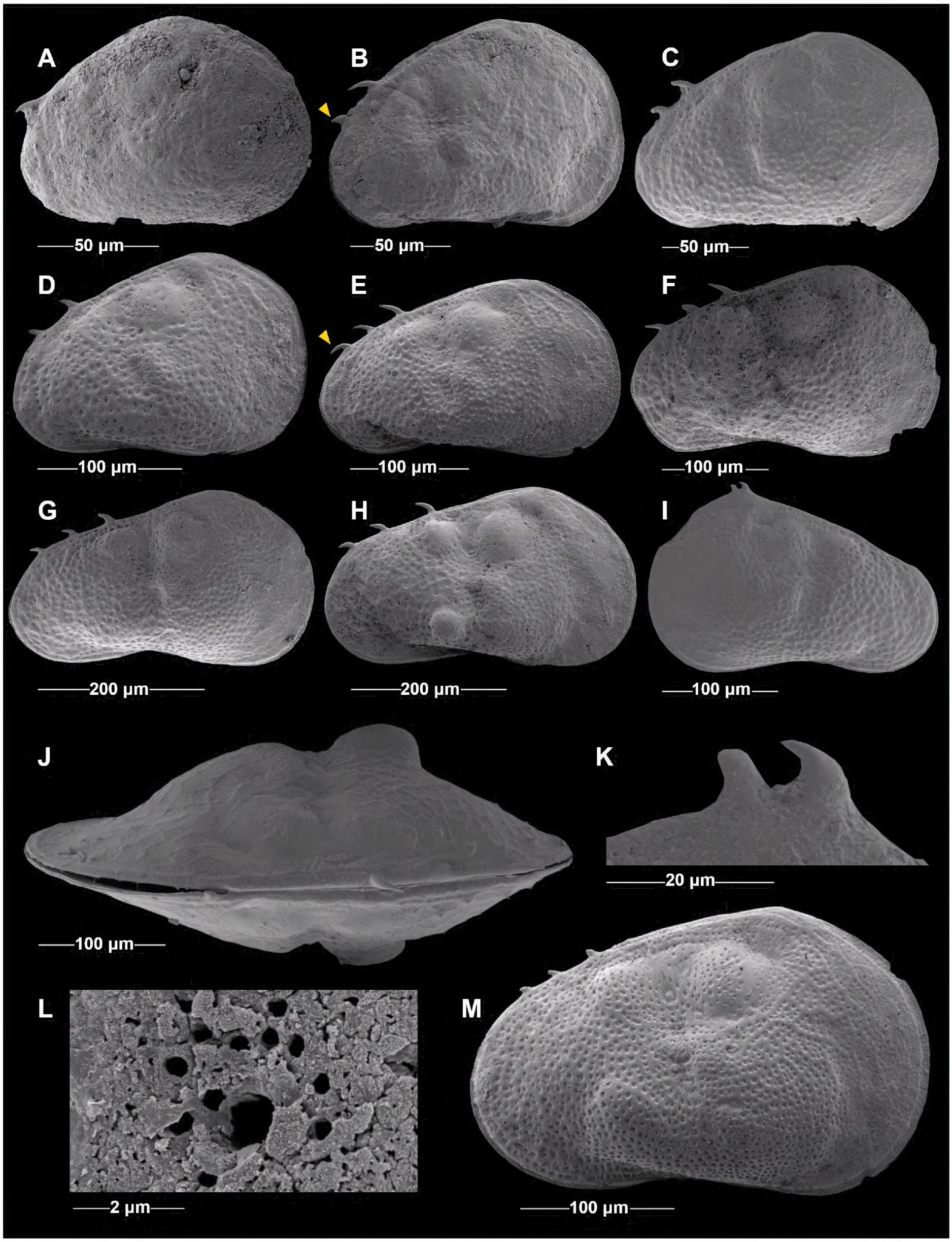

Figure 3. *Limnocythere curvispinosa* sp. nov. **A–H.** RV, ext of different developmental stages: **A.** Ad-7 (YZHA-a'1-53); **B.** Ad-6 (YZHA-a'1-45); **C.** Ad-5 (YZHA-a'1-19); **D.** Ad-4 (YZHA-a'1-51); **E.** Ad-3 (YZHA-a'1-18); **F.** Ad-2 (YZHA-a'1-50); **G.** Ad-1 (YZHA-a'1-25); **H.** Adult female (YZHA-a'1-31). Arrows in **B** and **E** indicate newly appeared spines at these stages; **I.** Ad-3 LV, ext (YZHA-a'1-39), a rare morphotype of LV with two antero-dorsal spines; **J.** Female carapace, oblique-dor (WOC444); **K.** Antero-dorsal spines of **I**; **L.** A sieve pore on **M** with seta decayed, revealing a cardinal pore; **M.** Ad-3 RV, ext (YZHA-a'5-01); **J.** A living specimen from Fuxian Lake; others, fossil material from core YZHA of Yangzong Lake.

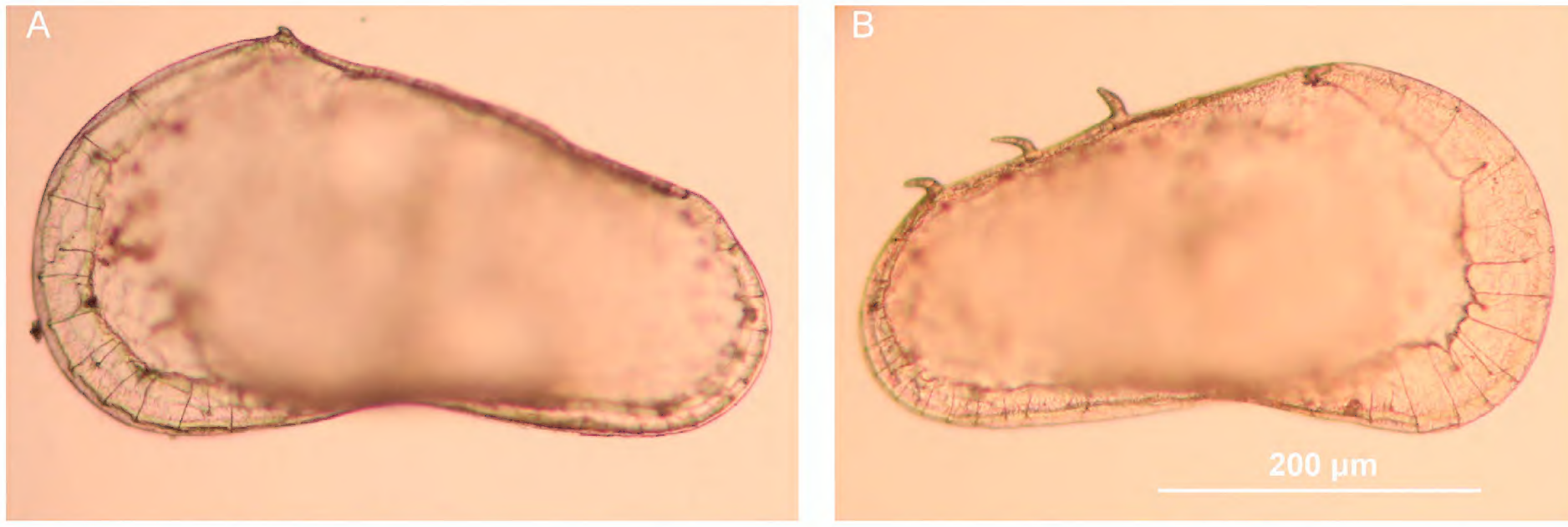

Figure 4. Valves of *Limnocythere curvispinosa* sp. nov. photographed with an XSP-12CA transmitted light microscope, showing the morphologies of the radial pore canals. **A.** Female LV, WOC455; **B.** Male RV, WOC694.

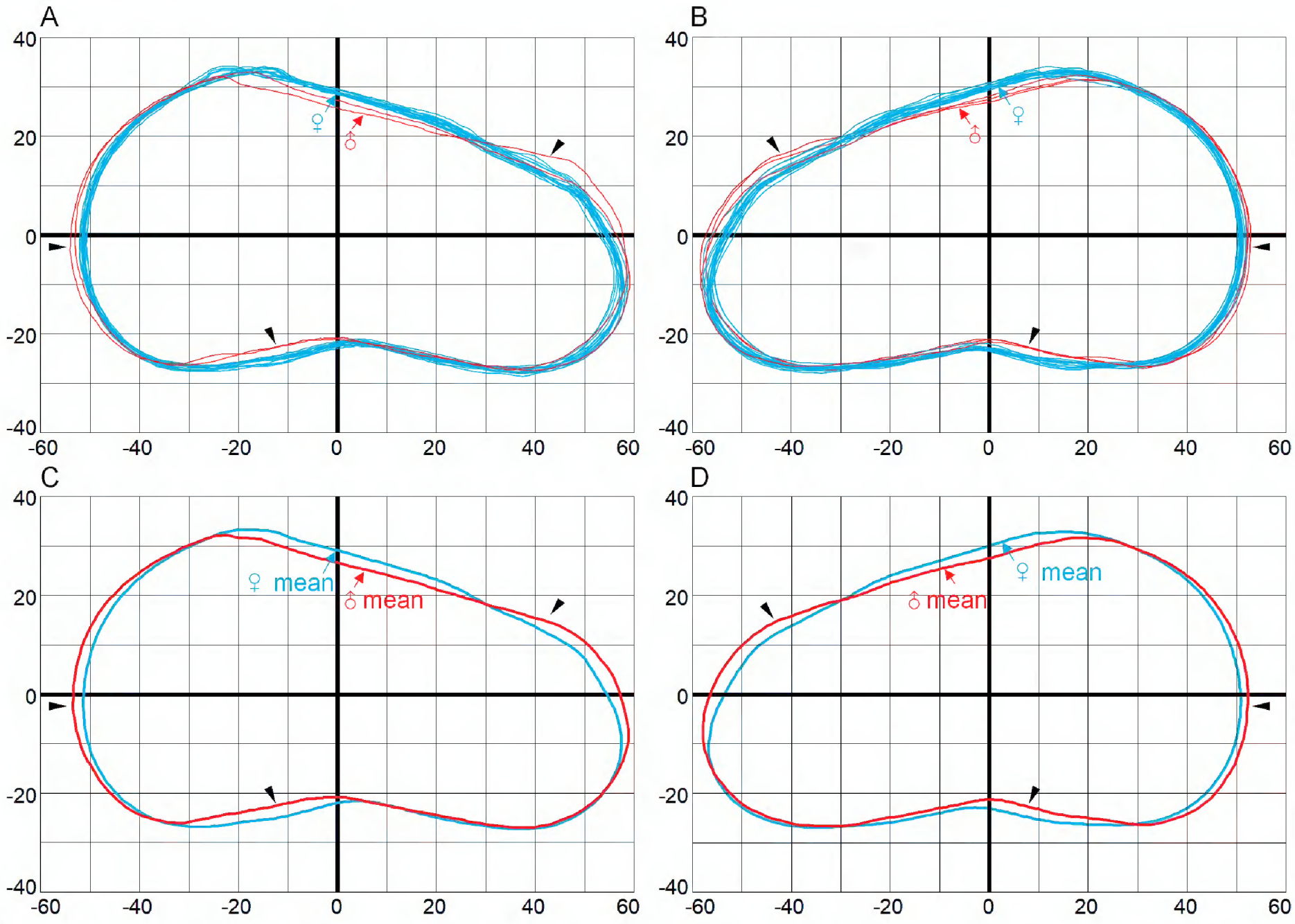

Figure 5. Comparison of the female and male outlines of *Limnocythere curvispinosa* sp. nov., dorsal spines eliminated. **A.** Fifteen female LVs and two male LVs; **B.** Fifteen female RVs and three male RVs; **C.** Mean outlines of the female and male LVs; **D.** Mean outlines of the female and male RVs. See Tables 2 and 3 for specimen information. Black arrowheads highlight major deviations between female and male outlines.

Free valve margins with compressed zone, which is wider along anterior margin than along posterior margin. Radial pore canals straight and unbranched, sparsely distributed along compressed zone (Fig. 4). False pore canals present. Sieve-type pore canals belonging to type C classified by Danielopol et al. (2018), consisting of sieve-plate and central seta (Figs 2G, 3L). Proximal shaft of seta densely annulated (Fig. 2G). Hinge lophodont (cf. Danielopol et al. 1989), consisting of undivided anterior and posterior teeth and median groove in RV (Fig. 2D, H, I), and anterior and posterior sockets and fine median ridge in LV (Fig. 2C).

Male valves more elongate than female (Fig. 2E, F). Dorsal margin less inclined (Fig. 5), with sloping angle of 13.5°–18.4°, comparing to 17.6°–21.1° of female (Tables 2, 3). Ventral margin of male more widely concave than female (Fig. 5).

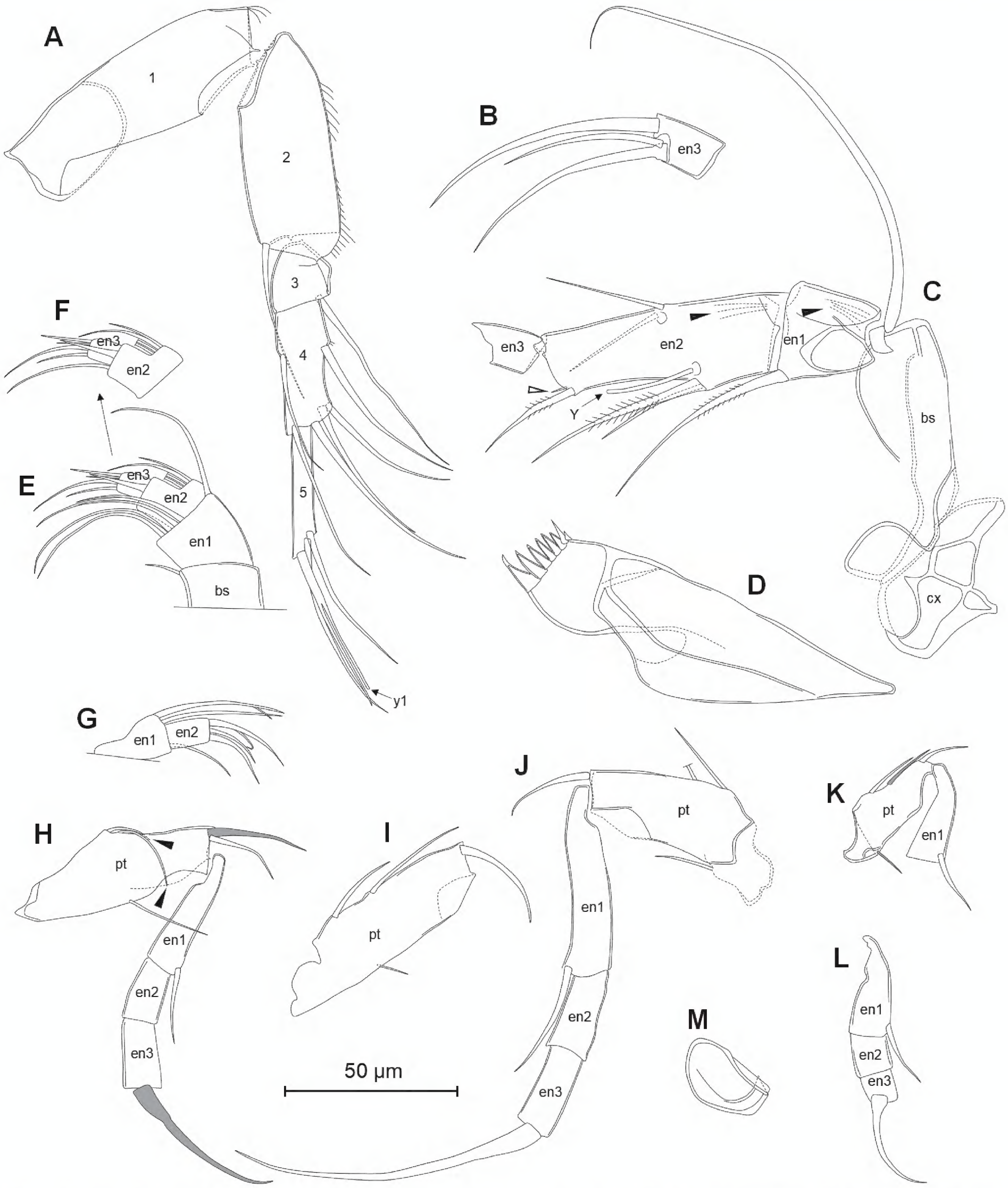

Figure 6. Inner-part morphology of female *Limnocythere curvispinosa* sp. nov. from Fuxian Lake, China. **A.** A1 (WOC441, holotype). Numerals indicate segments; **B.** Distal segment and claws of A2 (WOC444); **C.** A2 (WOC441, holotype). Distal claws not preserved. The proximal part of the basis is slightly damaged. Solid arrowheads indicate pseudochaetae on the first two endopodal segments. A hollow arrowhead indicates a small ventro-apical seta on the penultimate segment; **D.** Mandibular coxa (WOC441, holotype), interdental seta lost; **E.** Basis and endopod of mandible (WOC453); **F.** Two distal segments of **E**; **G.** Endopod of Mx (WOC453); **H.** L5 (WOC445). One of the knee setae and the distal claw (grey) flipped in the slide and was digitally flipped back to normal orientation in this line drawing; **I.** Protopod of L6 (WOC443); **J.** L6 (WOC445). The two distal segments and the claw displaced in the slide are digitally connected to the proximal part. Note the size variation of the ventral protopodal seta between **I** and **J**; **K.** Protopod and first endopodal segment of L7 (WOC431, female). One of the dorsal setae and the ventral seta (grey) of the protopod are not clearly seen, drawn based on other specimens; **L.** Endopod of L7 (WOC431, female); **M.** Genital lobe (WOC451).

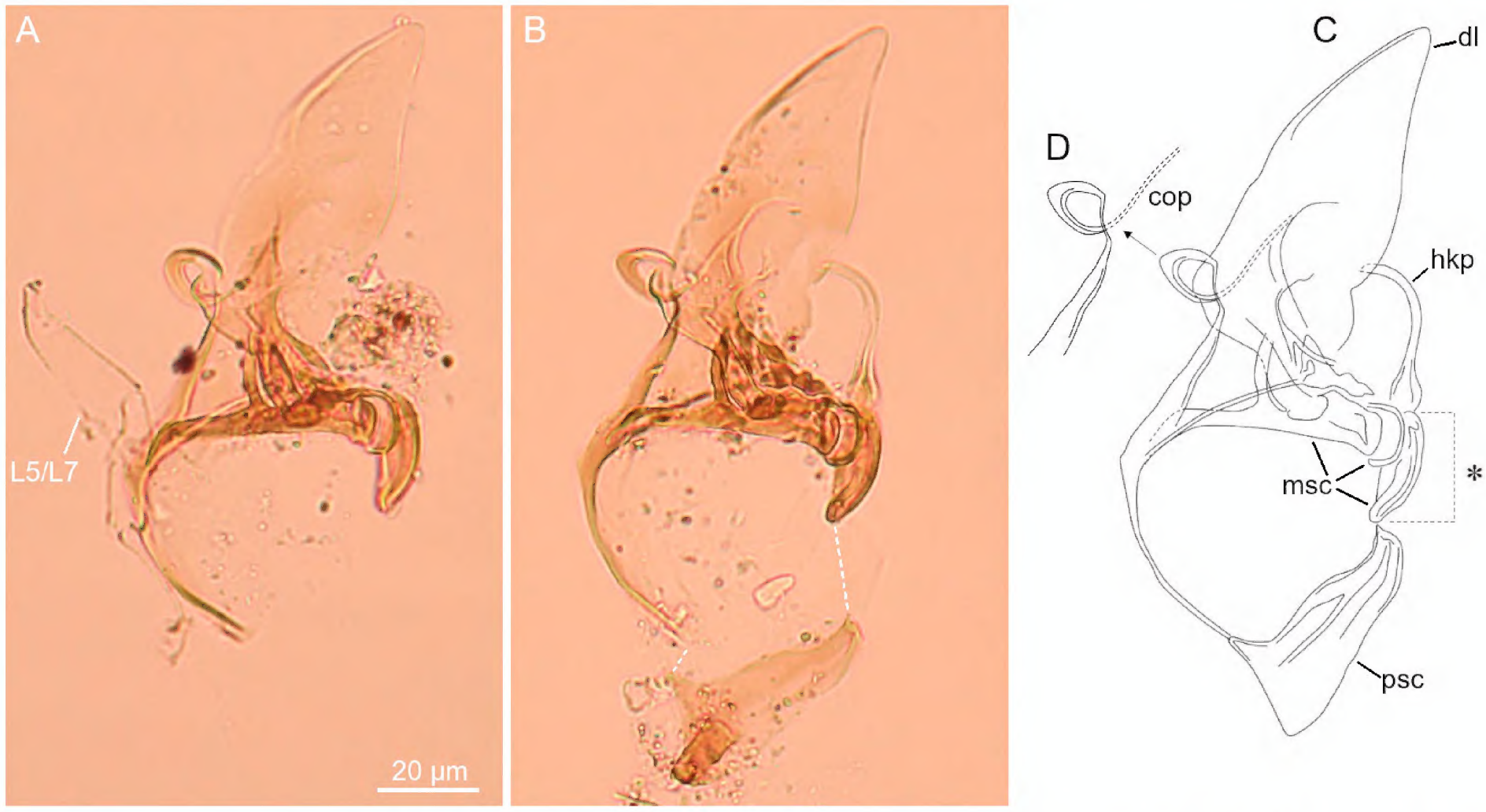

Figure 7. Hemipenes of the male of *Limnocythere curvispinosa* sp. nov., WOC694. **A.** Hp. Proximal sclerite and hook-like process not preserved; **B.** Hp of the other side. Proximal sclerite displaced (dashed lines); **C.** Line drawing of **B**. Proximal sclerite digitally restored; **D.** Copulatory process. Scale applies to all panels.

Brief description of ontogenetic change of valve morphology (Fig. 3A–H): From Ad-7 (Ad-8 not investigated) to the adult, valve shape generally becoming more elongate and dorsal margin becoming less inclined. RV of Ad-7 already with one dorsal spine (Fig. 3A). Second spine appearing in Ad-6 (Fig. 3B). Third spine appearing in Ad-3 (Fig. 3E). Proposed length ranges of different developmental stages as in Suppl. material 1.

A1 (Fig. 6A) with five segments. First segment robust, anteriorly directed. Other segments ventrally directed. Second segment elongate, carrying one postero-apical seta extending almost to distal end of fourth segment. Second segment with densely arranged short pseudochaetae along anterior margin. Third segment short, bearing one antero-apical seta. Fourth segment elongate, consisting of two sections. Proximal section short and stout, with one antero-apical and one postero-apical seta. Distal section more elongate and slightly narrower, with three antero-apical setae and one postero-apical seta. Fifth segment slender, with two antero-apical setae and branched postero-apical y1. Aesthetasc branch of y1 slightly shorter than setal branch.

Limb stem of A2 (Fig. 6B, C) consisting of coxa, basis, and three endopodal segments. Basis apically carrying spinneret seta (exopod) extending somewhat beyond terminal segment. First endopodal segment short and stout, with one ventro-apical setae. Second endopodal segment elongate, consisting of two sections. Proximal section with two dorso-apical setae and three ventro-apical setae, one being very weakly sclerotised aesthetasc (Y). Distal section with two unequal ventro-apical setae, one sometimes very small (hollow arrowhead in Fig. 6C). Pseudochaetae present on dorsal areas of first and second endopodal segments and sometimes showing appearance of small setae (Fig. 6C, solid arrowheads). Third endopodal segment (distal segment) with three unequal claws (Fig. 6B). Distal claws of male not preserved; therefore, potential sexual dimorphism [i.e., distally bifurcated claw of male *Limnocythere stationis* Vávra, 1891 recorded by Smith and Janz (2009)] not verified.

Md coxa (Fig. 6D) elongate, endite distally with eight processes. First six processes tooth-like, strongly sclerotized and progressively shorter. Rest two processes slender, seta-like. One short seta present between two largest processes (lost in specimen illustrated in Fig. 6D due to preservation). Palp (Fig. 6E, F) consisting of basis and three endopodal segments. Basis with one short ventro-apical seta. First endopodal segment with one dorsal seta and four ventro-apical setae. Second endopodal segment with four unequal dorsal setae, one short thick lateral seta, and one ventro-apical seta. Third endopodal segment with four unequal setae/claws.

Mx endopod (Fig. 6G) 2-segmented. First segment comparatively short, with three anterior setae and one posterior seta. Second segment with four setae. Protopod with three setose endites and one respiratory plate fringed with rays (not illustrated because of weak sclerotisation and overlap).

L5–L7 (Fig. 6H–L) with similar chaetotaxies. L6 > L5 > L7 in length. Protopod robust, with two proximo-dorsal setae and two (L5) or one (L6 and L7) apical seta, plus one proximo-ventral seta. Size of proximo-ventral seta somewhat variable among specimens (e.g., Fig. 6, I vs. J). First endopodal segment elongate, with one antero-apical seta. Second and third segments much shorter, without seta. Fourth segment very small, fused with distal claw.

GL (Fig. 6M) of each side somewhat saddle-like, with simple half coil internally.

Table 2. Information on the living specimens of *Limnocythere curvispinosa* sp. nov. from Fuxian Lake used for valve geometric morphometric analysis. For most of the specimens, both the RV and LV were analyzed. The LV of WOC686 was broken and was not used. Bold signifies male.

Collection number	Site and date	Sex	RV L (µm)	RV H (µm)	RV H/L	RV D_H/L	RV SA	LV L (µm)	LV H (µm)	LV H/L	LV D_H/L	LV SA
WOC441	Y394-20240824	♀	441	234	0.531	0.317	19.0°	443	237	0.535	0.335	19.4°
WOC442	Y394-20240824	♀	439	241	0.549	0.326	20.0°	442	243	0.550	0.336	19.2°
WOC443	Y394-20240824	♀	416	227	0.546	0.313	18.7°	420	230	0.548	0.329	18.4°
WOC445	Y394-20240824	♀	417	233	0.559	0.336	20.4°	421	235	0.558	0.337	20.9°
WOC451	Y394-20240824	♀	458	253	0.552	0.304	18.8°	464	257	0.554	0.329	18.2°
WOC452	Y394-20240824	♀	446	244	0.547	0.380	19.8°	447	248	0.555	0.336	18.6°
WOC453	Y394-20240824	♀	441	243	0.551	0.334	19.5°	446	247	0.554	0.356	19.0°
WOC454	Y394-20240824	♀	451	249	0.552	0.306	19.9°	452	251	0.555	0.342	19.8°
WOC455	Y394-20240824	♀	453	246	0.543	0.317	20.7°	456	247	0.542	0.333	20.4°
WOC686	Y546-20250522	♀	424	227	0.535	0.353	19.0°	429	na	na	na	na
WOC687	Y546-20250522	♀	423	238	0.563	0.365	20.8°	424	239	0.564	0.303	19.4°
WOC694	**Y474-20250222**	♂	**430**	**230**	**0.535**	**0.307**	**18.4°**	**437**	**233**	**0.533**	**0.321**	**17.5°**
WOC695	Y474-20250222	♀	465	256	0.551	0.390	21.1°	469	256	0.546	0.345	20.3°

Table 3. Information on the fossil valves of *Limnocythere curvispinosa* sp. nov. from the sediment core YZHA used for geometric morphometric analysis. Bold signifies male.

Collection number	Depth in core (cm)	Sex	RV or LV	L (µm)	H (µm)	H/L	D_H/L	SA
YZHA-a'1-26	30.0–31.0	♀	LV	420	235	0.560	0.268	18.1°
YZHA-a'1-27	30.0–31.0	♀	LV	426	241	0.566	0.279	17.6°
YZHA-a'1-28	30.0–31.0	♀	LV	407	234	0.575	0.260	18.4°
YZHA-a'1-29	**30.0–31.0**	♂	**LV**	**411**	**213**	**0.518**	**0.263**	**13.5°**
YZHA-a'1-30	30.0–31.0	♀	LV	404	231	0.572	0.272	18.4°
YZHA-a'1-31	30.0–31.0	♀	RV	422	242	0.573	0.337	18.7°
YZHA-a'1-32	**30.0–31.0**	♂	**RV**	**423**	**219**	**0.518**	**0.324**	**15.7°**
YZHA-a'1-33	30.0–31.0	♀	RV	415	238	0.573	0.339	19.6°
YZHA-a'1-35	**114.0–115.0**	♂	**RV**	**426**	**227**	**0.533**	**0.306**	**13.6°**
YZHA-a'1-36	114.0–115.0	♀	RV	427	243	0.569	0.340	18.3°

Hp of male (Fig. 7) dagger-shaped, consisting of rounded proximal section and relatively slender distal section. Median area of inner margin with slightly curved sclerite [marked with asterisk in Fig. 7C, see also same structures of *Limnocythere* species illustrated by Smith and Janz (2009)]. A slender hkp with swollen base attached to distal end of this sclerite. Cop with one full coil medially and fine tube distally extending into dl, which is sub-triangular in shape and with nearly pointed end.

Brush-shaped organs of male not preserved.

Differential diagnosis. The presence of posteriorly curving dorsal spines on RV distinguishes the new species from almost all congeners. The small spine on the antero-dorsal corner of LV is another diagnostic feature. *Limnocythere dorsosicula* De Deckker, 1981 from Australia also has dorsal spines on RV (De Deckker 1981). However, those spines are relatively shorter and thinner than the spines of *L. curvispinosa* sp. nov. and are variable in number (three to six). In our new species, no RV has more than three dorsal spines. A few RV from the core have less than three dorsal spines, but taphonomic loss of spines cannot be excluded. In addition, *L. dorsosicula* lacks the antero-dorsal spine on LV. But the most significant differences between *L. dorsosicula* and the new species are seen in the internal morphology. The A1 of *L. dorsosicula* has six segments, compared to five in the new species. The proximo-ventral seta on the prodopodal segment of the walking legs is tiny or even absent in *L. dorsosicula*. Also, in *L. dorsosicula*, L7 is longer than L5 (fig. 1F, G of De Deckker 1981; but see our Discussion section), while in the new species, L5 is longer than L7. The Hp of *L. dorsosicula* is stouter than that of the new species and has a curved appearance. The above differences unambiguously separate *L. dorsosicula* from the new species. *Limnocythere xinanensis* Zhao, 1987, recovered from the Pleistocene to Recent strata of Caohai Lake of Guizhou Province adjacent to Yunnan, sometimes also carries three dorsal spines on RV (fig. 2 of pl. 14, 130 of Zhao 1987). However, our geometric morphometric analysis indicates that *L. xinanensis* is stouter than *L. curvispinosa* sp. nov. and has a less inclined dorsal margin (Suppl. material 2). Such differences create dissimilarities of 1.9% (RV) and 1.7% (LV) from the new species, values much higher than the intraspecific variation (0.9%) of the new species (Suppl. material 3). In addition, the LV of *L. xinanensis* lacks the antero-dorsal spine seen in the new species.

Population dynamics of *Limnocythere curvispinosa* sp. nov. in Yangzong Lake during the Holocene

We analyzed 25 sediment samples from cores YZHA and YZHB (Fig. 8), which span from 25 cal ka BP to the present day. Our data indicate that *L. curvispinosa* sp. nov. colonized Yangzong Lake no later than 11,580 cal yr BP, near

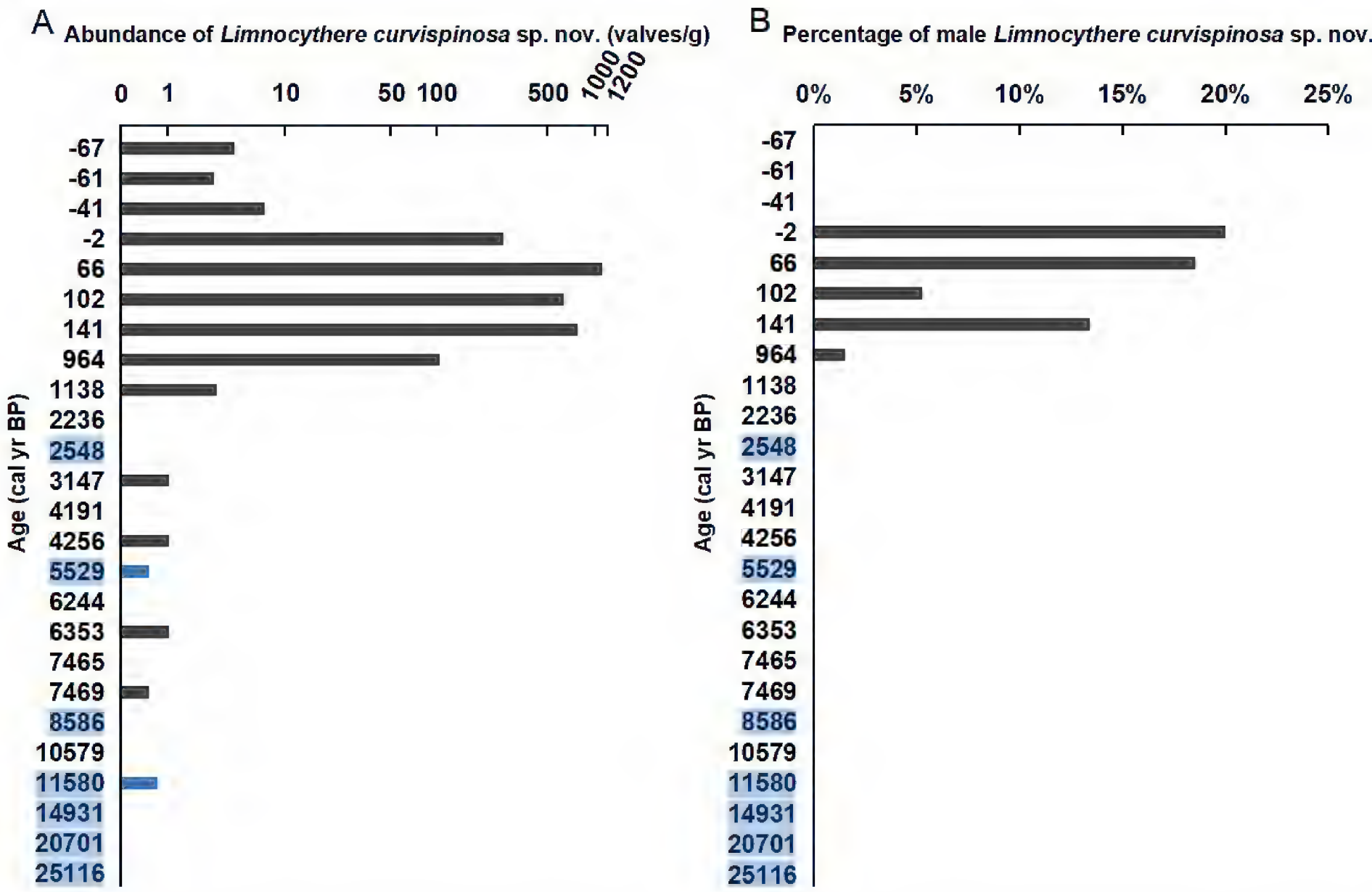

Figure 8. A. Abundances of valves of *Limnocythere curvispinosa* sp. nov. in 25 samples from cores YZHA (abundance bars and age values shown in black) and YZHB (abundance bars and age values shown in blue) of Yangzong Lake, China. The samples are arranged by age along the vertical axis. The abundance values on the horizontal axis are shown with a logarithmic scale [log (abundance + 1)]; **B.** Percentages of males in the population of *L. curvispinosa* sp. nov. in Yangzong Lake during the Late Holocene. Only Ad-1 and adult valves are included in the calculation (sex is difficult to determine in younger instars). No males were found in the samples before the Late Holocene, although this may be due to low specimen numbers. Negative age values indicate years after 1950 AD.

the beginning of the Holocene. During the Early Holocene to the mid-Late Holocene, the population density remained very low, with no more than 1 valve/g (Fig. 8A). The valve abundance began to increase at 1138 cal yr BP (812 AD), exceeding 100 valves/g between 964 and −2 cal yr BP (986–1952 AD), with a maximal value of 1087 valves/g at 66 cal yr BP (1884 AD). The abundance of *L. curvispinosa* sp. nov. decreased to below a level of 10 valves/g since −41 cal yr BP (1991 AD). Only two valves of *L. curvispinosa* sp. nov. were recovered from the samples of −61 and −67 cal yr BP (2011 and 2017 AD), the youngest samples analyzed in this study.

Males of *L. curvispinosa* sp. nov. were observed in five samples, between 964 and −2 cal yr BP (986–1952 AD) (Fig. 8B), coinciding with the abundance peak of this species (Fig. 8A). The percentage of males in the population attained 20% in samples of −2 cal yr BP (1952 AD), meaning that the male-to-female ratio reached ca. 1:4 at that time.

Modern ostracod fauna of the Yangzong Lake area

To further assess the distribution of *L. curvispinosa* sp. nov. in the study area, 15 surface samples from the Yangzong Lake area (Table 1) were analyzed. A total of 506 living ostracod individuals were picked, including 400 individuals from the lake and 106 individuals from the small waterbodies near the lake (Table 1). The extant ostracod fauna in the lake is overwhelmingly dominated by *Cypridopsis vidua* O.F. Müller, 1776 (98.3%), accompanied by sporadic *Physocypria kraepelini* G.W. Müller, 1903, *Limnocythere* sp., and *Timiriaseviinae* sp. (Table 1). In the small waterbodies near Yangzong Lake, the ostracods are more diverse, containing abundant *P. kraepelini*, *C. vidua*, *Stenocypris* sp., *Fabaeformiscandona subacuta* (Yang 1982 in Hou et al. 1982), and a few *Heterocypris incongruens* (Ramdohr 1808) and *Ilyocypris* sp. (Table 1). *Limnocythere curvispinosa* sp. nov. was not observed in these modern samples from the Yangzong Lake area.

Discussion

A small evolutionary lineage within the *Limnocythere stationis* group

Within the genus *Limnocythere*, species of the *L. stationis* group are characterized by the posteriorly inclined dorsal valve margin and the reduced L7, which is otherwise the longest walking leg in the congeners (Martens

1990). The two features are possibly coupled, as the sloping dorsal margin results in a narrow posterior area that requires the reduction of L7. Another feature of this group is the frequent occurrence of dorsal spines on the RV (Table 4). Based mainly on carapace length and the morphology of RV dorsal spines, we propose that the *L. stationis* group can be further divided into two subgroups. Species of the first subgroup have longer Cp (usually > 400 μm) and often three or more relatively long spines on the RV. The Cp lengths in the second subgroup are usually < 400 μm, and with the exception of *L. notodonta* Vávra, 1906, their RVs have no more than two small spines (Table 4).

Limnocythere curvispinosa sp. nov. and *L. xinanensis* Zhao, 1987 belong to the first subgroup (Table 4). The two species are closely related to each other not only because of the size of the Cp and the morphology of RV spines, but also because of their close geographical and stratigraphical occurrences. The latter species was found in the Pleistocene to Holocene deposits of Caohai Lake in western Guizhou Province adjacent to Yunnan, where *L. curvispinosa* sp. nov. is herein found. A third member(s) of this subgroup is/are specimens misidentified as *L. subornamenta* Hou in Hou et al. (1982) by Liu and Lu (1999, pl. I, figs 10–12), recovered from the Lower Pleistocene of eastern Yunnan. The specimens illustrated by Liu and Lu (1999), including one LV (fig. 10 therein) and two RVs (figs 11, 12 therein), have straight and posteriorly inclined dorsal margins, and the two RVs bear three and six dorsal spines (some spines broken off, leaving stubbles), respectively. These features clearly differ from the smooth, rounded, and subhorizontal dorsal margin of *L. subornamenta* and suggest affinity with the first subgroup of the *L. stationis* group (Table 4). The two RVs of *L. subornamenta* sensu Liu and Lu (1999) illustrated therein differ from each other by the H/L ratio (0.616 vs. 0.542). The H/L ratio of the former specimen (fig. 11 op. cit.) is significantly larger than those of *L. curvispinosa* sp. nov. and the latter specimen (fig. 12 op. cit.) and may represent a juvenile (less likely, because of the similar lengths of ca. 0.5 mm for all three specimens illustrated therein) or a separate species. The H/L ratio of the latter falls well within the range of females of the new species (Tables 2, 3). Furthermore, this specimen shows an average dissimilarity value of only 1.0% with the female RVs of *L. curvispinosa* sp. nov. (Suppl. material 3). We suggest that this specimen could potentially represent a yet undescribed species closely related to *L. curvispinosa* sp. nov., or alternatively, it might actually belong to the latter species. Additional specimens from the same stratum need to be investigated to justify the nomenclature of *L. subornamenta* sensu Liu and Lu (1999). Based on the above observations, we conclude that a small lineage of *Limnocythere*, belonging to the abovementioned first subgroup of the *L. stationis* species group, colonized the Yunnan–Guizhou Plateau in SW China since at the latest the Early Pleistocene and could be viewed as a native ostracod element in this area. Future studies describing more related species, both extant and fossil, in this area would help to resolve the evolutionary history of this lineage.

Limnocythere dorsosicula De Deckker, 1981, was also assigned to the *L. stationis* group (Martens 1990), yet it is somewhat peculiar for this group. According to the description of De Deckker (1981), the L7 of *L. dorsosicula* is the longest walking leg, which is different from all other species of the *L. stationis* group. However, the designation of the three walking legs of this species in fig. 1E–G of De Deckker (1981) may be erroneous, because the designated L6 (fig. 1G therein) may in fact be L5, judged from the presence of two knee setae. Therefore, fig. 1E, F, G of De Deckker (1981) could instead be L6, L7, and L5 of the holotype, respectively, with the size relation being L6 > L5 > L7. If this is correct, then the walking legs of *L. dorsosicula* would have the characteristic size pattern of the *L. stationis* group. Consequently, it may be put in the first subgroup of the *L. stationis* group in view of the Cp length and the number and size of dorsal spines on the RV (Table 4). The inner parts of *L. dorsosicula* need to be reexamined to verify the above suggestion.

Table 4. Morphological comparison of some *Limnocythere* species of the *L. stationis* group.

Species	Cp length (μm)	RV dorsal spines	LV antero-dorsal spine	Size of L5 and L7	References
L. curvispinosa sp. nov.	400–450	3, long	Present	L5 > L7	Present study
L. xinanensis Zhao, 1987	Female 400–500	3, 1, or 0, length not clear	Absent	Unknown	Zhao (1987)
L. subornamenta sensu Liu and Lu (1999, pl. I, figs 10–12)	450–550	3–6, long	Absent	Unknown	Liu and Lu (1999)
L. dorsosicula De Deckker, 1981	400–450	3–6, long	Absent	L7 > L5 (but see discussion)	De Deckker (1981)
L. notodonta Vávra, 1906	Female 300–350	2–4, short	Absent	L5 > L7	Vávra (1906), Martens (1990)
L. levigatus Smith & Janz, 2009	Female around 400, male 300–350	2, short	Absent	L5 > L7	Smith and Janz (2009)
L. fude Smith & Janz, 2009	300–350	2, short	Absent	L5 > L7	Smith and Janz (2009)
L. cyphoma Smith & Janz, 2009	300–350	0	Absent	L5 > L7	Smith and Janz (2009)
L. kamiyai Smith & Janz, 2009	Female 350–400, male 300–350	2 (male), short	Absent	L5 > L7	Smith and Janz (2009)
L. stationis Vávra, 1891	350–400	2 or 0, short	Absent	L5 > L7	Vávra (1891), Martens (1990), Meisch (2000), Smith and Janz (2009), Fuhrmann (2012)

Nonetheless, *L. dorsosicula* is likely different from the abovementioned evolutionary lineage represented by *L. curvispinosa* sp. nov. in view of its stouter female carapace, shorter dorsal spines on the RV, and the inner-part morphologies mentioned above (see "Differential diagnosis").

Possible environmental indication

Our analysis of valve remains of *L. curvispinosa* sp. nov. from the sediment cores of Yangzong Lake (Fig. 8) indicates that this species colonized the lake no later than the Early Holocene. While we did not find this species in the three samples of the Late Pleistocene, additional analyses are required to verify its absence during that period. Although the low temporal resolution of the analyzed samples during the Early Holocene to ca. 1138 cal yr BP may fail to capture potential short-period abundance peaks, it may be concluded that in general *L. curvispinosa* sp. nov. remained low in abundance during the Early Holocene, the Middle Holocene, and most of the Late Holocene (Fig. 8).

The underlying environmental cause for the peak abundance of *L. curvispinosa* sp. nov. between 964 and −2 cal yr BP (986–1952 AD) is currently not fully understood. The beginning and ending of this period did not coincide with the timings of the Medieval Climate Anomaly (950–1250 AD) or the Little Ice Age 1400–1700 AD (Mann et al. 2009). Yet the past millennium is a period of intensified human activities in the lake area (Yiliang County Local Chronicles Compilation Committee 1998), and the observed population dynamics of *L. curvispinosa* sp. nov. during this period were potentially related to human impacts. For example, the excavation of the inflowing Baiyangshan Canal in 1955 AD (Yiliang County Local Chronicles Compilation Committee 1998) could be correlated with the ending of the peak abundance of *L. curvispinosa* sp. nov. around 1952 AD. The urbanization and industrialization of the lake area in the second half of the 20th century coincided with the low abundances of this ostracod species. Some studies reported multiple human-induced events of abnormal water quality in the second half of the 20th century, such as water eutrophication, acidification in the lake, and heavy metal pollution (Wang et al. 2003, 2005; Zhang et al. 2012a, 2012b; Wu et al. 2021). However, analyses of the remains of other aquatic organisms, including other ostracods, are needed to verify the impacts of human activities on the lake's ecosystem and to understand the exact mechanisms.

While the peak abundance in Yangzong Lake may be linked to human activities or hydrological change, the reproductive strategy of the species appears to vary by lake, potentially reflecting differences in habitat stability. The population of *L. curvispinosa* sp. nov. in Yangzong Lake includes males during the peak-abundance period of 964–−2 cal yr BP (986–1952 AD). In other time intervals, the adults and Ad-1 juvenile individuals (which allow for sexual determination) are too few, and we cannot determine the presence or absence of males. Yet it can be concluded that the Yangzong population of this species exhibited sexual reproduction at least during the majority of the past millennium (986–1952 AD). In contrast, only one male was found among the 69 late-instar individuals analyzed from Fuxian Lake (Table 1), suggesting that the majority of the individuals of *L. curvispinosa* sp. nov. of Fuxian Lake have asexual reproduction. Previous studies on other nonmarine ostracods (Griffifths and Butlin 1995; Martins et al. 2008, 2009; Schmit et al. 2013) suggest that fluctuating environments would favor sexual reproduction, whereas a relatively stable environment would potentially favor asexual reproduction. Yangzong Lake is shallower and smaller than Fuxian Lake, with a smaller catchment area (see "Study area"). Consequently, Yangzong Lake may be more sensitive to climate- and human-induced environmental changes than Fuxian Lake, whose profundal habitats may be more capable of buffering fluctuations in environmental parameters such as temperature and water chemistry. As a result, the difference in the reproductive mode of *L. curvispinosa* sp. nov. between the two lakes may reflect differences in the stability of the lake environment.

Acknowledgments

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Supplementary material 1

Frequency distribution histogram of valve length of the instars of *Limnocythere curvispinosa* sp. nov. in the sediment core YZHA of Yangzong Lake, China

Authors: Ping Jiang, Qianwei Wang, Dingkuan Ge, Manping Xie, Lizeng Duan, Jiawei Fan, Dayou Zhai

Data type: tif

Explanation note: Adult instar: 405–470 μm; Ad-1: 340–405 μm; Ad-2: 280–340 μm; Ad-3: 235–280 μm; Ad-4: 200–235 μm; Ad-5: 170–200 μm; Ad-6: 140–170 μm; Ad-7: 110–140 μm; Ad-8: < 110 μm. The small number of Ad-8 instars is presumably due to its poorly calcified, soft carapace, which should have low preservation potential.

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Link: https://doi.org/10.3897/zse.101.168416.suppl1

Supplementary material 2

Comparison of the outlines of *Limnocythere* species

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Data type: tif

Explanation note: **A.** Mean outlines of the female LVs of *L. curvispinosa* sp. nov. and a female LV (holotype) of *L. xinanensis* Zhao, 1987. **B.** Mean outlines of the female and male RVs of *L. curvispinosa* sp. nov., a female RV of *L. xinanensis* Zhao, 1987, and a female RV of *Limnocythere* identified as *L. subornamenta* Hou, 1982 by Liu and Lu (1999, pl. I, fig. 12). Dorsal spines eliminated for all the outlines. See Suppl. material 3 and text for details.

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Link: https://doi.org/10.3897/zse.101.168416.suppl2

Supplementary material 3

Supplementary data

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Data type: xlsx

Explanation note: Dissmilarity matrices of the valve outlines of the specimens of *Limnocythere curvispinosa* sp. nov. and selected congeners.

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